CHEMICAL STERILIZATION

The sterilizing efficiency of chemical sterilants depends to a great extent on environmental factors. Opfell (27) has given careful consideration to the application of chemicals in spacecraft sterilization. He noted that chemicals should be considered only if physical agents such as heat and radiation are not compatible with spacecraft components. Factors limiting sterilant efficiency were discussed. Recommendations were made for improving the reliability of sterilization processes.

Chemicals can readily pasteurize soil (30), but sterilization of soil is difficult to achieve. Formaldehyde is the best agent other than steam for retaining soil properties. A formaldehyde-steam sterilization process has been described (35).

Gaseous Sterilants.

A useful review of ethylene oxide sterilization procedures was compiled by Stierli, Reed and Billick (43). Bruch (Annual Review of Microbiology, v. 15, pp. 245-262, 1961) reviewed biological action of gaseous sterilants and discussed numerous medical, agricultural and industrial applications of gaseous sterilization.

Jaffe (169) observed that ethylene oxide gas is compatible with most spacecraft components, but penetration is limited. On relating population reduction factors with ethylene oxide kill

curves, Jaffe concluded that there is insufficient evidence to show that ethylene oxide can produce high probabilities of sterility in spacecraft applications.

Tessler (40) found that several plastics are damaged by gas sterilization, and recommended that the stability of plastics be determined under conditions which would indicate gross damage.

Pan and Gast (39) described a procedure for determining the antimicrobial activity of gases. Their technique may be suitable for confirming the reliability of a gas sterilization process considered for spacecraft assembly, and intermediate or terminal sterilization.

A method for sterilizing and protecting surgical instruments from recontamination was developed by Montgomery and Morelli (49) as a space-oriented technique. The instruments are dipped into an ethylene oxide-liquid plastic mixture which subsequently forms a solid polymer film retaining residual ethylene oxide.

Opfell et al. (42) concluded that convection was necessary as well as diffusion for a gas to reach sterilizing levels at a remote surface in a confined space.

Humidity and Temperature. The interplay of humidity and temperature and the concentration of the gaseous sterilant are prime considerations in any gaseous sterilization process. These parameters are important for single gases and for mixtures of gases such as ethylene oxide

and propylene oxide or ethylene oxide and methylene bromide (37, 38).

Bomar (41) showed that dried Bacillus subtilis spores stored for 8-14 days had far greater resistance to ethylene oxide than 0-4 day-old preparations.

El-Bisi and his associates (45-47) studied the influence of moisture, humidity and temperature on ethylene oxide sterilization.

Brown and Fuerst (44) demonstrated that more than 24 hours were required at 37 C to kill large inocula of Aerobacter aerogenes, Escherichia coli, Bacillus megaterium bacteriophage, and a yeast in 1 percent ethylene oxide at 60-80 percent relative humidity.

Ionizing Radiation. Phillips (34) reported that the lethality of several gas phase and liquid phase germicides is enhanced by ionizing radiation. A potentially useful sterilizing treatment combined ethylene oxide and 100,000 rad or less ionizing radiation.

Liquid Sterilants.

Jaffe (169) discussed limitations of liquid sterilants, and cited a number of factors which influence their effectiveness. A discussion of spacecraft assembly techniques considered the chance of contamination under clean room conditions.

Willard and Alexander (48) incorporated formaldehyde in a Surveyor thermal control coating which cannot be gas sterilized. This coating, however, did not always sterilize the surface in

contact.

Beta-propiolactone (BPL) is an efficient liquid and vapor phase sterilant (24-26). The chemical will corrode certain metals and plastics (25) but hydrolyzes in water to harmless substances. LoGrippo and Hartman (26) found less BPL and ultraviolet were required together for virucidal action than each agent individually.

Peracetic acid is a useful surface sterilant (29) that has been used in conjunction with anionic detergent. Wuhrmann and Meyrath (36) observed the superiority of ozone over chlorine dioxide and hypochlorite as germicides. The sporicidal action of alcohol is heightened by any of several acids and bases (32). Several reports (27, 33, 145) note the importance of temperature control in the use of germicides.

Miscellaneous Chemical Applications.

An electric current was found by Rechmenskii (59) to activate the sterilizing action of mercury compounds on Bacillus anthracis spores so that less time or a lower concentration of the agent was required.

Fungi in cooling tower wood were killed in 2 hr at 145-160 F (63-71 C) (68). A phenolic bactericide was then crystallized on the sterilized wood to retard future attack.